Plant Archives Vol. 24, No. 2, 2024 pp. 2316-2320 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.330

EFFECT OF NANO-UREA ON VEGETATIVE GROWTH, FLOWERING, FRUITING AND YIELD OF STRAWBERRY FRUIT CV. WINTER DAWN

Manish Kumar Sonkar[1*], Goutam Mandal[1], Navdeep Kumar[2], Kotapati Priyanka[1], Madhu Kumar[1], Prateek[2] and Dhan Singh[2]

[1]Department of Horticulture and Post-harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan-731236, West Bengal, India.
[2]Department of Horticulture, SASRD, Nagaland University, Medziphema-797106, Nagaland India.
*Corresponding author Email: manishkeshriya@gmail.com
(Date of Receiving-08-02-2024; Date of Acceptance-24-04-2024)

ABSTRACT

A field experiment was carried out in randomized block design (RBD) with three replications at the Horticulture Farm of the Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal, during 2022–23 with the objective of finding out the effect of nano-urea on the growth, flowering, fruiting and yield of strawberries. The experiment had seven treatments, where different concentrations of nano-urea were sprayed. In the plots where 50% of RDN was applied through urea, two foliar sprays of nano-urea were done and the plots where 100% RDN was applied through urea, only one foliar spray of nano-urea was done. Plots where only urea was applied to fulfil 100% RDN were considered control plots. The results of the study revealed that a combination of 100% RDN through urea with one foliar spray of different concentrations of nano-urea enhanced growth, flowering, fruiting and yield compared to the control. The plots treated with one foliar spray of 0.4% nano-urea with 100% RDN through urea had the best results in all the growth, flowering, fruiting and yield parameters, whereas the plots treated with 50% RDN through urea and two foliar sprays of different concentrations of nano-urea had inferior results in growth, flowering, fruiting and yield than the control plot.

***Key words*: Strawberry, nano-urea, nitrogen, nano-fertilizer and winter Dawn.**

Introduction

The cultivated Strawberry (*Fragaria* × *ananassa* Duch.) member of the Rosaceae family, an octaploid species (2n = 8x = 56) belonging to a French native, is the most popular and economically valuable fruit crop worldwide, renowned for their delectable taste, vibrant colour, and numerous health benefits. In the current scenario, the global demand for strawberries continues to rise, driven by their versatile use in various culinary applications and the growing awareness of their nutritional advantages. It has been reported that global strawberry production increased by 39.4% between 2008 and 2018, and it is anticipated that it could increase again by 3.4% between 2021 and 2026 (Oguz *et al.*, 2022). However, the production of strawberries is not an easy task; it depends on so many factors, like environmental factors, agronomic factors, economic factors, etc. In agronomic factors, nutrient management is considered an important factor, and nitrogen (N) is considered the most important nutrient in achieving a higher yield of quality produce. Yoshida *et al*., (1991) reported that the management of nitrogenous fertiliser in strawberry production can directly affect the vegetative growth, flowering, fruiting, yield, and quality of the strawberries. In present farming practices, urea is used most extensively to supply nitrogen in plants due to its high N content (46% N) as well as its compatibility with other nutrients, but due to the high N loss and its low use efficiency, only 45-50% of nitrogen is used effectively in modern farming methods (Iqbal *et al.*, 2019), and it forces the farmers to use more N fertilisers in order to improve crop output, which increases the costs of farming as well as having an adverse impact

Table 1: Treatment detail and schedule of application of treatments.

Treat-ment	Treatment detail	Schedule of application of treatments			
		Basal dose	30 DAT	45 DAT	60 DAT
T_1	100% of RDN by U (control)	50% of RDN by U	25% of RDN by U	25% of RDN by U	-
T_2	50% of RDN by U + Two F. A. of 0.2% N-U	50% of RDN by U	0.2% N-U	0.2% N-U	-
T_3	50% of RDN by U + Two F. A. of 0.3% N-U	50% of RDN by U	0.3% N-U	0.3% N-U	-
T_4	50% of RDN by U + Two F. A. of 0.4% N-U	50% of RDN by U	0.4% N-U	0.4% N-U	-
T_5	100% of RDN by U + One F. A. of 0.2% N-U	50% of RDN by U	25% of RDN by U	25% of RDN by U	0.2% N-U
T_6	100% of RDN by U + One F. A. of 0.3% N-U	50% of RDN by U	25% of RDN by U	25% of RDN by U	0.3% N-U
T_7	100% of RDN by U + One F. A. of 0.4% N-U	50% of RDN by U	25% of RDN by U	25% of RDN by U	0.4% N-U
Note: U= urea, N-U = Nano-urea, F.A.= foliar application					

on the environment. In response to these challenges, the agricultural sector has witnessed a paradigm shift towards the development and utilisation of nanotechnology in agriculture. Nano-based agricultural products, such as nanofertilizer, offer innovative solutions to enhance crop performance while minimising environmental impacts (Lal, 2008). In light of this, Indian Farmers Fertiliser Cooperative Limited (IFFCO) has created a new nanofertiliser called IFFCO nano-urea (liquid) with the intention of replacing or minimising the negative impacts of the application of urea. This new fertiliser molecule has been evaluated on a variety of crops in various research institutes and state agricultural universities, as it has been discovered that the majority of crops are reacting well to nano-urea (Kumar *et al.*, 2021). Therefore, this study was attempted with the aim of exploring and elucidating the potential impact of different concentrations of nano-urea on the vegetative growth, flowering, fruiting, and yield of strawberries.

Materials and Methods

A field experiment was conducted during 2022-23 at the Horticultural Farm under the Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva Bharati, Sriniketan, West Bengal. The site lies at 23° 42’ N latitude, 87° 40’ 30" E longitude and 40 m above mean sea level. The experimental site was situated in the sub-humid, subtropical lateritic belt of West Bengal, with a hot summer and a moderately cold and short winter in the eastern part of India. The average weekly maximum and minimum temperature during the cropping seasons (15 October to 15 March) varied from 22.19 to 33.33°C and 9.60 to 22.71°C, respectively. Soil is Gangetic alluvium having loamy sand in texture with pH 4.97, EC 0.28 ds/m and organic carbon 0.6%, Alkaline Potassium Permanganate - N, Bray’s - P and Ammonium acetate extraction - K content of surface soil was 237.44, 17.13 and 114.68 kg/ha, respectively. Winter dawn variety of strawberry and IFFCO nano-urea liquid (4% w/v) was used as a source of nano-nitrogen fertiliser in the experiment. The experiment was laid out in a randomized block design with three replications and seven treatments. Treatment details and the schedule of treatment applications are given below in Table 1. To analyse the effect of nano-urea, different concentrations of nano-urea were sprayed either once or twice. In the plots where only 50% RDN was applied as a basal application of urea, two foliar sprays of different concentrations of nano-urea were sprayed at 30 and 45 DAT, while in the plots where 100% RDN was applied through urea as a basal application and soil application at 30 and 45 DAT, only one foliar application of different concentrations of nano-urea was sprayed at 60 DAT. Plots where only urea was applied to fulfil 100% RDN were considered control plots.

Manure and fertiliser application were done following the recommendation of Saini *et al.*, (2022) and Dhillon (2013) of 50 metric tonnes FYM and 80-40-40 kg N-P_2O_5-K_2O per ha. A full dose of FYM, P_2O_5, K_2O and half doses of N were applied at the time of land preparation through single superphosphate (SSP), murate of potash (MOP), and urea, respectively, while the remaining half of N was applied based on the treatments. Urea and other fertilisers were applied as soil applications, whereas nano-urea was dissolved in water and applied in the form of foliar spray with the use of a knapsack sprayer (25 knapsack sprayer or 375 l solution/ha).

Five strawberry plants were selected randomly and marked in each plot for observation. Observations on plant spread in the east-west and north-south directions (cm), number of leaves, root length (cm), fresh weight (g) and chlorophyll content in leaves were taken at 150 days after transplanting (DAT). Middle-aged leaves were taken to analyse chlorophyll content in the leaves with the help of a spad chlorophyll meter (Model # SPAD-502Plus, Make # KONICA MINOLTA, Japan) and the result was expressed in spad value. The number of flowers and fruits harvested from five selected plants at different

Table 2: Effect of various concentration of nano-urea on vegetative growth of strawberry plants.

Treatments	Plant spread (cm)		No. of leaves per plant	Fresh weight of plant (g)	Root length (cm)	Chlorophyll content (spad value)
	E-W	N-S				
T_1	30.03	31.90	24.23	150.17	33.00	48.87
T_2	21.60	21.87	15.80	45.83	9.67	40.10
T_3	23.93	25.10	16.53	60.33	13.00	43.83
T_4	25.47	26.20	20.33	83.50	23.33	46.13
T_5	32.07	32.77	27.63	160.00	39.67	53.23
T_6	34.07	35.33	29.60	171.50	43.00	53.37
T_7	36.93	38.40	31.17	182.00	46.33	54.27
SEm(±)	0.69	0.92	0.61	4.38	1.22	2.13
CD at 5%	2.02	2.70	1.81	12.93	3.60	6.28
CV (%)	4.08	5.25	4.50	6.23	7.11	7.59

intervals from each treatment was counted and weighted periodically. To get average fruit weight and yield per plant, all fruit weighted data was summed up and then the average was worked out. The duration of flowering was counted from the first flower appearance to the appearance of the last flower in marked plants.

The data on all the growth, flowering fruiting and yield were tabulated and subjected to statistical analysis by following the standard ANOVA method with a 5% level of significance described by Gomez and Gomez (1984) for randomized block design.

Results and Discussion

Effect of nano-urea on vegetative growth of strawberry plants

The result on vegetative growth parameters presented in Table 2 shows that one foliar spray of different concentrations of nano-urea with 100% RDN has a positive effect on the vegetative attributes of strawberry plants, while applying two foliar sprays of different concentrations of nano-urea with 50% RDN found less vegetative growth than the control. The highest number of strawberry leaves (31.17), plant spread in both the direction east-west (36.93 cm) and north-south direction (38.40 cm), root length of plants (24.47 cm), chlorophyll content (54.27), and fresh weight of strawberry plant (182.00 g) were observed in treatment T_7 followed by T_6 and T_5, while the lowest number of leaves (15.80), plant spread in east-west (21.60 cm) and north-south direction (21.87 cm), root length (12.00 cm), chlorophyll content (40.10) and fresh weight of strawberry plants (45.83 g) were observed in treatment T_2 followed by T_3 and T_4.

The increased number of leaves, plant spread and root length in strawberry plants might be due to a rapid increase in cell division and cell elongation activities by supplying an additional dose of nitrogen via foliar spray of nano urea at the peak vegetative growth stage of strawberry plants. The smaller size of nitrogen particles could potentially reduce the risk of toxicity and facilitate efficient nutrient uptake and soil fertility restoration (Nongbet *et al.*, 2022). A similar result was observed by Midde *et al.*, (2022) and Velmurugan *et al*., (2021) in rice, who reported increased tiller number and root length respectively, with the application of nano-urea.

Positive effect on the chlorophyll content in the leaves of strawberry plants; this could be due to the higher availability of nitrogen molecules through the application of nano-urea, which may play a critical role in the

Table 3: Effect of various concentration of nano-urea on flowering and fruiting of strawberries.

Treatments	Duration of flowering (days)	Number of flower/plant	Number of fruits/plant	Average fruit weight (g)	Yield per plant(g)
T_1	98.80	19.83	13.80	21.60	297.66
T_2	86.37	14.60	10.97	11.23	122.03
T_3	89.37	16.23	11.80	12.33	145.21
T_4	90.23	17.97	13.40	13.53	181.86
T_5	101.77	21.23	15.10	22.50	339.97
T_6	100.37	21.53	15.77	25.07	393.98
T_7	102.70	23.70	16.33	26.77	436.26
SEm(±)	1.49	1.00	0.73	0.95	15.46
CD at 5%	4.38	2.94	2.15	2.81	45.61
CV (%)	2.69	8.95	9.10	8.69	9.78

formation of chlorophyll by being involved in enzyme activation and amino acid synthesis (Chu *et al.*, 2007). The present findings are in association with the findings of Uysal (2018) in apples and Silva Junior *et al.*, (2013) in orchids, who reported that chlorophyll content in leaves was increasing with increasing nitrogen doses.

The increment in fresh weight of strawberry plants might be due to significant improvements in all the growth parameters, such as plant spread, number of leaves, root length, etc. The present findings are in association with the findings of Midde *et al.*, (2022), who reported in rice that the application of nano-urea increased dry matter production. Rajonee *et al.*, (2016) reported a higher dry weight of *Ipomoea aquatica* (*Kalmi*) plants treated with nano-nitrogen fertiliser.

Effect of nano-urea on flowering and fruiting of strawberry

The result on flowering and fruiting attributes presented in Table 3 shows that one foliar spray of different concentrations of nano-urea with 100% RDN has a positive effect on flowering and fruiting attributes of strawberries, while the result from the application of two foliar sprays of different concentrations of nano-urea with 50% RDN was not satisfactory with flowering and fruiting attributes and was found to be less than the control. The maximum duration of flowering (102.70 d), number of flowers (23.70), number of fruits (16.33), average strawberry fruit weight (26.77 g) and yield (436.26 g) per plant were recorded in the treatment T_7 (100% RDN + one spray of 0.4% nano-urea) followed by T_6 and T_5, while the minimum duration of flowering (86.37 d), number of flowers (14.60), number of fruits (10.97), average strawberry fruit weight (11.23 g) and yield (122.03 g) per plant were recorded with T_2 (50% RDN + two sprays of 0.2% nano-urea), followed by T_3 and T_4.

The observed maximum duration of flowering and number of flowers might be due to the healthy and vigorous growth of strawberry plants enhanced by additional nitrogen fertilisation through nano-urea spray that stored sufficient amounts of photosynthates, which promoted early flowering in strawberry plants, which continued up to a later stage of crop growth. Other than this, it has also been observed that nitrogen can enhance localised cytokinin biosynthesis in plants (Ding *et al.*, 2014), and an increased level of cytokinin can regulate the number of flowers in plants (Barazesh and McSteen, 2008). The research results are in conformity with the findings of Kaur and Kumar (2001) in the verbena plant and Dogra and Sirohi (2020) in the pansy plant; they reported that increasing the levels of nitrogen increased the duration of flowering and the number of flowers per plant.

The behaviour of increasing the number of fruits, average fruit weight and fruit yield might be due to the application of an additional dose of nitrogen to the strawberry plants in combination with nano-urea because nitrogen is an important component of enzymes, vitamins, and chlorophyll molecules and is involved in nucleic and amino acid synthesis and protein production, which is important for cell growth and development. Nitrogen also affects the absorption and distribution of all other nutrients in the plant that are particularly important to the tree during flowering, fruit set, and development (Carranca *et al.*, 2018). The results obtained were in conformity with the findings of Reddy and Goyal (2020) in strawberry, who reported an increased number of fruits and average fruit weight with an increase in levels of nitrogen.

Conclusion

Based on the findings obtained from the present investigation on vegetative growth, flowering, fruiting and yield of strawberry fruit, it was realised that application of nano-urea in place of urea or replacing the dose of urea with nano-urea can limit growth, flowering, fruiting and yield of strawberries, but a combination of one foliar spray of nano-urea at the peak vegetative growth stage with 100% RDN through urea can enhance the vegetative growth, flowering, fruiting and yield of strawberries. Hence, the present investigation concludes that a combination of 100% RDN through urea with one foliar spray of 0.4% nano-urea at the peak vegetative growth stage is more beneficial to achieve higher vegetative growth, flowering, fruiting and yield of strawberries.

Acknowledgement

The authors would like to thank Department of Horticulture and Post-harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati for providing all necessary facilities to carry out the work.

References

Barazesh, S. and McSteen P. (2008). Hormonal control of grass inflorescence development. *Trends in Plant Science*, **13(12)**, 656-662. https://doi.org/10.1016/j.tplants.2008.09.007

Carranca, C., Brunetto G. and Tagliavini M. (2018). Nitrogen nutrition of fruit trees to reconcile productivity and environmental concerns. *Plants*, **7(1)**, 4. https://doi.org/10.3390/plants7010004.

Chu, H., Hosen Y. and Yagi K. (2007). NO, N_2O, CH_4 and CO_2 fluxes in winter barley field of Japanese Andisol as affected by N fertilizer management. *Soil Biology and Biochemistry*, **39(1)**, 330-339. https://doi.org/10.1016/j.soilbio.2006.08.003.

Dhillon, W.S. (2013). Fruit production in India. Narendra Publishing House, Delhi. 638-639.

Ding, C., You J., Chen L., Wang S. and Ding Y. (2014). Nitrogen fertilizer increases spikelet number per panicle by enhancing cytokinin synthesis in rice. *Plant Cell Reports* **33**, 363-371. https://doi.org/10.1007/s00299-013-1536-9.

Dogra, S. and Sirohi H.S. (2020). Influence of nitrogen levels and plant geometry on growth, flowering and seed production in pansy (*Viola tricolor* Hortensis) variety snow white. *The Pharma Innovation Journal*, **9(7)**, 596-599.

Gomez, K.A. and Gomez A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons Inc, New York. 357-427.

Iqbal, M., Umar S. and Mahmooduzzafar (2019). Nano-fertilization to enhance nutrient use efficiency and productivity of crop plants. *Nanomaterials and plant potential*, 473-505. https://doi.org/10.1007/978-3-030-05569-1_19.

Kaur, K. and Kumar R. (2001). Effect of nitrogen and phosphorus on verbena. *Journal of Ornamental Horticulture*, **4(1)**, 59-60.

Kumar, Y., Singh T., Raliya R. and Tiwari K.N. (2021). Nano Fertilizers for Sustainable Crop Production, Higher Nutrient Use Efficiency and Enhanced Profitability. *Indian Journal of Fertilisers*, **17(11)**, 1206-1214.

Lal, R. (2008). Promise and limitations of soils to minimize climate change. *Journal of soil and water conservation,* **63(4)**, 113A-118A. https://doi.org/10.2489/63.4.113A.

Midde, S.K., Perumal M.S., Murugan G., Sudhagar R., Mattepally V.S. and Bada M.R. (2021). Evaluation of Nano-urea on Growth and Yield Attributes of Rice (*Oryza Sativa* L.). *Chemical Science Review and Letters*, **11(42)**, 211-214.

Nongbet, A., Mishra A.K., Mohanta Y.K., Mahanta S., Ray M. K., Khan M. and Chakrabartty I. (2022). Nanofertilizers: a smart and sustainable attribute to modern agriculture. *Plants*, **11(19)**, 2587. https://doi.org/10.3390/plants11192587

Oguz, I., Oguz H.I. and Kafkas N.E. (2022). Strawberry cultivation techniques. IntechOpen, London, UK. http://dx.doi.org/10.5772/intechopen.104611

Rajonee, A.A., Nigar F., Ahmed S. and Huq S.I. (2016). Synthesis of nitrogen nano fertilizer and its efficacy. *Canadian Journal of Pure and Applied Sciences*, **10**, 3913-3919.

Reddy, G. and Goyal R.K. (2020). Growth, yield and quality of strawberry as affected by fertilizer N rate and bio fertilizers inoculation under greenhouse conditions. *Journal of Plant Nutrition*, **44(1)**, 46-58. https://doi.org/10.1080/01904167.2020.1806301

Saini, S., Kumar P., Sharma N.C., Sharma N. and Balachandar D. (2021). Nano-enabled Zn fertilization against conventional Zn analogues in strawberry (*Fragaria× ananassa* Duch.). *Scientia Horticulturae*, **282**, 110016. https://doi.org/10.1016/j.scienta.2021.110016

Silva Júnior, J.M.D., Rodrigues M., Castro E.M.D., Bertolucci S.K.V. and Pasqual M. (2013). Changes in anatomy and chlorophyll synthesis in orchids propagated in vitro in the presence of urea. *Acta Scientiarum Agronomy*, **35**, 65-72. https://doi.org/10.4025/actasciagron.v35i1.15356

Uysal, E. (2018). Effects of nitrogen fertilization on the chlorophyll content of apple. *Meyve Bilimi*, **5(1)**, 12-17.

Velmurugan, A., Subramanil T., Bommayasamy N., Ramakrishna, Kumar M. and Swarnam T.P. (2021).The effect of foliar application of Nano-Urea (liquid) on rice (*Oryza sativa* L.). *Journal of the Andaman Sciences Association*, **26(2)**, 76-81.

Yoshida, Y., Ohi M. and Fujimoto K. (1991). Fruit malformation, size and yield in relation to nitrogen nutrition and nursery plants in large-fruited strawberry (*Fragaria x ananassa*). *Journal of the Japanese Society of Horticultural Science* **59(4)**, 727-35. https://doi.org/10.2503/jjshs.59.727